Section 3: Biological Monitoring

Photos Courtesy of the Virginia Department of Conservation and Recreation and Alliance for the Chesapeake Bay

Chapter 7

Benthic Macroinvertebrates

What Are Benthic Macroinvertebrates?

Damselfly larva.

Benthic macroinvertebrates are organisms that live on the bottom of a body of water (benthic), lack a backbone (invertebrate) and are visible to the eye (macro). Benthic macroinvertebrates include insects in their larval or nymph stages, crustaceans (such as Crayfish), and mollusks (such as clams).

Why Monitor Benthic Macroinvertebrates?

Volunteer monitoring programs in wadable, nontidal freshwater streams commonly monitor benthic macroinvertebrates. They are good indicators of water quality because:

- They are affected by the physical, chemical, and biological conditions of the stream.
- They show the effects of short and long-term pollution events.
- They may show the cumulative impacts of pollution.
- They may show impacts from habitat loss not detected by traditional water quality assessments.
- They are important in the food web of the stream.
- Some are very intolerant of pollution; while others are tolerant of pollution.
- They are relatively easy to monitor.

Benthic macroinvertebrate monitoring is often a popular choice for volunteer monitoring programs in nontidal freshwater streams because it is generally less expensive than other kinds of monitoring and the monitoring events can be less frequent while showing cumulative effects. Many volunteers, especially children, enjoy collecting "bugs."

What Do Your Macroinvertebrate Results Mean?

The study of benthic macroinvertebrates generally includes collecting samples from the habitat(s) of the organisms and identifying and sorting the organisms in the collection. After all organisms have been identified (to order or family depending upon methodology), a water quality index may be calculated depending upon the methodology you choose to use. The calculation of the water quality index varies from one methodology to another but the end result may be a number that corresponds to a water quality rating.

Information about the sources of pollution cannot be obtained from a single macroinvertebrate survey alone. Sources of pollution can be inferred from a macroinvertebrate study by incorporating a habitat and watershed assessment and looking at conditions upstream and downstream of potential sources of pollution. While chemical monitoring can only describe water quality at the moment the water is monitored, the macroinvertebrate community shows cumulative impacts.

Sampling Considerations

Stream with riffles *(photo courtesy of VA Save Our Streams)*.

There are two programs in Virginia that provide training and certification of volunteers for macroinvertebrate monitoring: the Virginia Save Our Streams Program (VA SOS) and the Audubon Naturalist Society (ANS). These methods are appropriate for nontidal, wadeable freshwater streams with riffles (areas where the water bubbles over the rocks) generally located west of the fall line (parallels I-95) in Virginia.

In 2001, VA SOS began using a modified method based upon a two-year scientific study of the traditional Save Our Streams method. This two-year study resulted in changes to the collection and identification procedures to yield results that more closely matched those obtained when using professional methods (please see http://www.vasos.org/ValidationStudy.htm for a copy of the study by Engel and Voshell, 2002). Although VA SOS trains and certifies volunteers across Virginia in the modified method (where appropriate geographically), the traditional method may still be used for educational purposes only. Monitoring results obtained by certified VA SOS monitors using the modified VA SOS method are used by the Virginia Department of Environmental Quality (DEQ) for water quality assessments.

The ANS uses a modified version of the U. S. Environmental Protection Agency (EPA) Rapid Bioassessment II Protocol (this professional method is described later in this chapter) for macroinvertebrate collection and habitat assessment. ANS provides training and certification for volunteers in Northern Virginia, including macroinvertebrate identification to order and family levels, protocol implementation, and habitat assessment. Training is offered at their sanctuaries in Fairfax and Loudoun Counties. Monitors work in teams led by a certified leader. Monitoring results obtained using the ANS method are used by DEQ for water quality assessments.

Volunteers collecting macroinvertebrates in eastern Virginia *(photo courtesy of Alliance for the Chesapeake Bay)*.

Additionally, VA SOS in conjunction with Randolph-Macon College is developing a protocol for macroinvertebrate monitoring in nontidal, freshwater streams that lack riffles as found in central and eastern Virginia. Once this method is developed this manual will be updated (contact VA SOS at http://www.vasos.org for further information). Although benthic macroinvertebrates are found in tidal and estuarine (salt) waters of Virginia, there is currently no method appropriate for volunteers to use for monitoring these organisms.

In addition to the volunteer methods for macroinvertebrate monitoring, professional programs typically use methods known as Rapid Bioassessment Protocols (RBP) developed by the U. S. Environmental Protection Agency. RBP methods require identification of organisms to either the family level (RBP II) or the genus/species level (RBP III) and therefore, require extensive training as well as a lab for identification.

Please see *Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers; Periphyton, Benthic Macroinvertebrates and Fish*, second edition, EPA Publication 841-B-99-002, (http://www.epa.gov/owow/monitoring/rbp/) for more information.

Summary of Benthic Macroinvertebrate Monitoring Methods

Method	**Approximate Cost**	**Monitoring Level (see Appendix 9)**	**Organizations Using Method**
Modified Virginia Save Our Streams Method	One time purchase of basic monitoring equipment about $60 (includes net, waders, and other supplies) http://www.vasos.org/7equipchec.htm	I or II	Virginia Save Our Streams Program provides training and certification to interested organizations http://www.vasos.org
Traditional Virginia Save Our Streams Method	One time purchase of basic monitoring equipment about $60 (includes net, waders, and other supplies) http://www.vasos.org/equipchec.htm	I or II	Virginia Save Our Streams Program provides training to interested educational programs to interested organizations http://www.vasos.org
Audubon Naturalist Society	One time purchase of basic monitoring equipment about $241(includes net, field scope, and other supplies)	I or II	Audubon Naturalist Society provides training to interested individuals in Northern Virginia http://www.audubonnaturalist.org/rustsanct.htm

Chapter 8

Bacteria

What Are Bacteria?

Bacteria are single-celled organisms that occur in a variety of forms and have a wide range of properties. Some cause disease while others decompose decaying organic material and serve as food for other organisms in the food chain.

Why Monitor Bacteria?

Pathogenic (disease-causing) bacteria, viruses, and protozoans found in fecal waste can cause a variety of illnesses and diseases when ingested during recreational contact or consumed in contaminated water and shellfish. Fecal waste from humans or other warm-blooded animals may enter a waterbody from various sources including faulty wastewater treatment plants, livestock, malfunctioning septic systems, untreated sewage discharge, pets, stormwater runoff, wildlife, or boat waste. Since it is not practical to monitor every pathogen, "indicator" species are monitored. The presence of indicator species suggests the presence of fecal waste that may include pathogenic microorganisms that pose a health risk. In addition to the possible health risk associated with elevated levels of fecal material, it can also cause cloudy water, nutrient enrichment, unpleasant odors, and an increased oxygen demand (please see Chapters 4 and 6).

Which Bacterial Indicator Should You Use?

Bacterial indicators commonly measured by professional and volunteer monitoring programs include fecal coliform, *Escherichia coli* (*E. coli*) and enterococci. These indicators are normally prevalent in the fecal waste of warm-blooded animals and humans. This manual does not discuss monitoring total coliforms (*E. coli* and fecal coliforms belong to this larger group) since the presence of total coliforms does not necessarily indicate fecal contamination. However, total coliforms may be useful for testing drinking water because their presence indicates contamination of a drinking water supply by an outside source.

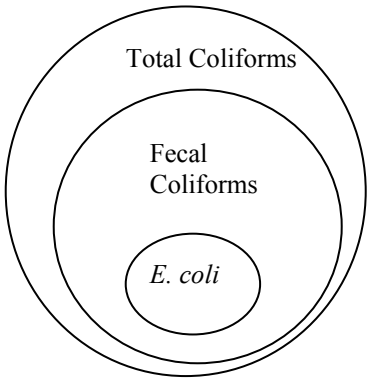

Figure 8-1. Relationship of bacterial indicators.

Fecal Coliform

Fecal coliforms, a subset of total coliform bacteria, are fecal-specific in origin. Even this group contains a genus, *Klebsiella*, with species that are not necessarily fecal in origin (often associated with textile or paper mill wastes). Fecal coliforms have historically been monitored by the Department of Environmental Quality (DEQ) as the indicator bacteria for surface waters. With the implementation of the new state water quality standard for bacteria, DEQ has begun to monitor more fecal-specific bacteria (*E. coli* and enterococci).

Escherichia coli (*E. coli*)

E. coli is a species within the fecal coliform group that is specifically associated with the fecal waste of warm-blooded animals. In freshwater, *E. coli* corresponds more closely with swimming-related illnesses than fecal coliforms. DEQ has begun monitoring *E.coli* at freshwater stations.

Enterococci

Enterococci are another group of bacteria found mainly in the intestinal tract of warm-blooded animals. It is not a type of coliform bacteria but a subgroup of the fecal streptococci group. Since EPA recommends enterococci for testing marine recreational waters because of correlation with swimming-related illnesses, DEQ has begun monitoring for enterococci at saltwater stations.

What Do Your Bacteria Results Mean?

A new water quality standard for bacteria was adopted by Virginia and became effective in January 2003 (Table 8-1). The new standard changes the indicator from fecal coliform to *E. coli* in freshwater and to enterococci in salt and transitional zone waters. During this transition to the new standard, a water quality standard for fecal coliform (revised from the old fecal coliform standard) will also apply until 12 or more data points for the new indicators are collected or until June 2008. After June 2008, only water quality standards for *E. coli* and enterococci will apply.

Table 8-1. Virginia Water Quality Standards for Bacteria (effective January 2003).

Indicator	**Single Sample**	**Revised Single Sample Standard**	**Geometric Mean*** (of 2 or more samples collected within same calendar month)
Fecal Coliform		10% of the number of samples taken during a calendar month should not exceed 400 colonies/100 ml water	200 colonies/100 ml water
E. coli (freshwater)	235 colonies /100 ml water		126 colonies/100 ml water
Enterococci (salt/transitional zone waters)	104 colonies/100 ml of water		35 colonies/100 ml of water

*The geometric mean can be calculated using the built-in formula in an Excel spreadsheet or by taking the nth root (where n= the number of data points) of the product of the individual data points.

Sampling and Quality Assurance/Quality Control (QA/QC) Considerations

Chapter 1 outlined a number of factors that every volunteer water quality monitoring program should consider. In addition to those summarized in Chapter 1, several considerations specific to monitoring for bacteria are discussed below.

Choosing a Method

Simplified Testing Methods

Presence-Absence Tests

These simple tests are designed to determine whether the target bacteria are present in a water sample. They are appropriate for educational purposes and for determining the presence of bacteria in drinking water. A variety of companies sell these test kits. Presence-absence tests are not used by any water quality monitoring programs in Virginia because they do not provide useful information for surface waters since bacteria are present in all surface waters.

Coliscan Easygel

Coliscan Easygel (Micrology Labs, Appendix 8) is simple to perform and relatively inexpensive. The Coliscan Easygel method measures total coliforms and *E. coli.* A water sample is added to a liquid medium and poured onto a treated Petri dish. Incubation is highly recommended. Inexpensive home-made incubators can be easily constructed.

The Coliscan Easygel method was compared to laboratory analysis and found to be an acceptable tool for screening purposes although the data cannot be used directly by DEQ for water quality assessments. This method is important because it can assist you in locating "hot spots" for fecal contamination and target areas for more extensive monitoring.

Colilert and Colilert-18

Colilert and Colilert-18 (Idexx Laboratories, Appendix 8) are based upon the most probable number method (see lab analysis section below) to detect the presence or absence of total coliforms and *E. coli.* The Colilert-18 method is for use in saltwater while Colilert is designed for freshwater. The U. S. Environmental Protection Agency (EPA) has approved this method for drinking water; but has not yet approved it for surface waters. At the time of publication of this manual, the Colilert method is under evaluation by DEQ. Bacterial data collected using this method will not be used by DEQ for water quality assessments until the method is

approved by EPA for surface water or comparison data demonstrates that the Colilert method produces data relatively comparable to an approved method.

Laboratory Analysis

At the time of the publication of this manual, bacterial monitoring data must be collected under a DEQ-approved quality assurance project plan (QAPP) where the samples are analyzed by a laboratory using a DEQ-approved analysis method to be included in DEQ's water quality assessments. Some water quality monitoring programs in Virginia conduct these laboratory tests themselves, while others send water samples to a commercial laboratory.

Membrane filtration of water sample for bacterial analysis *(photo by Katie Register)*.

Membrane Filtration (MF)

Membrane filtration (MF) is the laboratory method used by most volunteer monitoring groups. The MF procedure may not be useful in highly turbid waters since the filter can become clogged. For this method, the sample water is filtered and the filter is placed in a Petri dish along with a media ("food" for selected bacteria) and incubated. MF yields a direct count of bacteria colonies per 100 ml of water. This analysis method is often used to analyze water samples collected in freshwater areas. For more information on this procedure, please see Standard Method #9222D (APHA, 1998) for fecal coliforms and the EPA Method #1103.1 for *E. coli*.

Most Probable Number (MPN)

The most probable number (MPN) method is more commonly used in saltwater areas and is the only method approved for use in classifying shellfish-growing waters. This method is more expensive because it is labor intensive. A single water sample is added to a series of test tubes along with a media and incubated. Each test tube is determined to be positive or negative and the number of positive results corresponds to the probability that the water sample contained a specific (the most probable number) number of bacteria. For more information on this procedure, please see Standard Method #9221E for fecal coliforms and #9221F for *E. coli* (APHA, 1998).

Quality Assurance/Quality Control Issues

Sample Collection

It is preferred that you collect water samples for bacterial analysis directly from the stream, either by wading or using a pole with a holder for the sample bottle. If this is not possible for safety reasons, the water sample may be collected in a bucket or other

sterile container and transferred to the sterile sample container. Do not rinse sample bottles or collection device with sample water.

Some sample containers obtained from a lab contain a sodium thiosulfate tablet. This tablet is not necessary for surface water samples unless chlorine may be present. The purpose of the tablet is to neutralize chlorine in drinking water samples.

Field Equipment Blanks

Field equipment blanks are only necessary if water samples are collected in a bucket or other sampling device and transferred into the sample container. A field equipment blank is simply a contaminant-free sample (distilled or deionized water) used to detect contamination of the collection device or cross-contamination between sites. A field equipment blank is collected and transferred in the same manner as the stream water sample. It is recommended that field equipment blanks are collected randomly for 10% of your samples (for a large sample size, 5% is acceptable). For example, if you collect 50 samples, you should collect field equipment blanks at 5 of those sites and label the blank samples.

Field Duplicate Samples

Due to the nature of bacterial samples, a high degree of variation is normally expected in field duplicate samples. Therefore, DEQ does not recommend the collection of these samples.

Holding Time

A holding time of 26 hours is acceptable for ambient water quality samples (i.e. non-drinking water and non-enforcement samples). Samples must be chilled to less than 4ºC immediately after collection and stored in the dark.

Summary of Bacteria Monitoring Methods

Method	Approximate Cost	Monitoring Level Depends Upon DEQ Approval of QAPP (see Appendix 9)	Organizations Using Method
Various Presence-Absence Tests	$11	I	None known
Coliscan Easygel (measures *E.coli*)	$1.85 per sample	I	- Alliance for the Chesapeake Bay and affiliate organizations
Idexx Colilert (measures *E.coli*)	$20-$25 per sample	I	- Appomattox River Water Quality Monitoring Program (Clean Virginia Waterways / Longwood University)
Lab - Membrane Filtration	$20.00 per sample (*E. coli*)*	I, II, or III	- Appomattox River Water Quality Monitoring Program (Clean Virginia Waterways / Longwood University) - Ferrum College (Smith Mountain Lake & Claytor Lake Programs) - Upper Tennessee River Roundtable affiliate organizations
Lab - Most Probable Number	$20.00-70.00 per sample*	I, II, or III	- Virginia Department of Health Division of Shellfish Sanitation

*These costs are based upon submitting samples to the state laboratory, the Division of Consolidated Laboratory Services. This lab is only available to government organizations and nongovernmental organizations that receive state funding.

Chapter 9

Chlorophyll *a*

What is Chlorophyll a?

Chlorophyll is the pigment that allows plants (including algae) to undergo photosynthesis. Chlorophyll *a* is the predominant type of chlorophyll found in algae and phytoplankton (microscopic plants).

Why Monitor Chlorophyll a?

Chlorophyll *a* is measured to estimate the abundance of algae and phytoplankton in the water. Since chlorophyll *a* concentrations can vary among algal species and with differing light conditions, chlorophyll *a* is not considered a precise measurement of the abundance of algae. Large amounts of chlorophyll *a* indicate algal blooms that are caused by excessive nutrients as discussed in Chapter 6.

In lakes, chlorophyll *a* can be used to evaluate the trophic (aging) status of the lake. As lakes "age", the amount of plant and algal life that the lake can support increases as nutrients are added. Nutrients introduced from human activities can lead to an excessive amount of plant and algal life, which decreases water clarity and leads to interference with recreational activities and decreased dissolved oxygen levels as the plants decay.

What Do Your Chlorophyll a Results Mean?

The Department of Environmental Quality (DEQ) has begun to monitor for chlorophyll *a* suspended in the water column at some of its chemical (ambient) water quality monitoring stations, particularly in estuarine areas. DEQ currently designates "nutrient enriched waters" where there is degradation due to excessive nutrients. For tidal fresh waters, estuaries and lakes, the screening value for chlorophyll *a* is 50 ug/l (micrograms/liter), or 0.50 mg/l.

The higher the concentration of chlorophyll *a* present the more algae and phytoplankton present. Although large amounts of chlorophyll *a* indicate algal blooms, too little chlorophyll *a* would mean that not enough food is available for fish and aquatic animals.

Sampling and Quality Assurance/Quality Control (QA/QC) Considerations

Only a few citizen monitoring programs in Virginia measure this parameter since the water samples collected must be analyzed in a laboratory. Once collected, the water samples must be filtered under pressure within two hours of collection.

Sample Collection

Water samples for chlorophyll *a* analysis can be collected as grab samples (where a sample bottle is used to collect water at a particular depth) or as integrated samples (where a series of grab samples are taken at different depths and mixed together). An integrated sample may be collected by various methods: lowering a weighted sampler that collects water as it is lowered through the water column, using a pump to collect a water sample, or using a weighted hose that is crimped to capture the water.

Collecting a grab sample may be easier and less expensive; but in some situations, a single grab sample near the surface may not be representative of the algal biomass present. In shallower waters that are well-mixed, algae may be distributed evenly and a grab sample may be representative. However, in some waters algae may be distributed unevenly in the water column and an integrated sample would be preferable.

Depth

If you decide to collect an integrated sample, you will need to decide how deep to collect the water sample. Some programs, such as the Smith Mountain Lake Water Quality Monitoring Program coordinated by Ferrum College, collect the integrated sample through the photic zone. This is the depth in the water column where enough light penetrates to allow photosynthesis to occur and is usually estimated based on Secchi disk depth (usually one to 3.5 times the Secchi depth). Please see Chapter 12 for a description of how to measure water clarity using a Secchi disk. Sampling the upper warm water (epilimnion) and transitional water layers (thermocline) may also be appropriate. The thermocline is just below the epilimnion which prevents mixing of the warm epilimnion and the cooler bottom water of a lake.

Quality Assurance/Quality Control Issues

Chlorophyll *a* must be analyzed in a laboratory. Recommended QA/QC measures include:

- Proper Preservation: Samples should be filtered within two hours of collection. The filter can be frozen and kept in the dark for up to 28 days.
- Field duplicates: A field duplicate is simply a second water sample taken at the same time as another sample to measure the reproducibility of the monitor, method and/or analyst. It is recommended that you collect field duplicates randomly for 10% of your samples (for a large sample size, 5% is acceptable). For example, if you collect 50 samples, you should collect field duplicates at 5 of those sites and label the duplicate samples.
- Field equipment blanks are only necessary if water samples are collected in a bucket or other sampling device and transferred into the sample container. A field equipment blank is simply a contaminant-free sample (distilled or deionized water) used to detect contamination of the collection device or cross-contamination between sites. A field equipment blank is collected and transferred in the same manner as the stream water sample. It is

recommended that field equipment blanks are collected randomly for 10% of your samples (for a large sample size, 5% is acceptable).

Summary of Chlorophyll a Monitoring Methods

Method	**Approximate Cost**	**Monitoring Level Depends Upon DEQ Approval of QAPP (see Appendix 9)**	**Organizations Using this Method**
Laboratory	$12.00*	I or II	- Alliance for the Chesapeake Bay and affiliate organizations - Ferrum College (Smith Mountain Lake & Claytor Lake Programs)

*This cost is based upon submitting samples to the state laboratory, the Division of Consolidated Laboratory Services. This lab is only available to government organizations and nongovernmental organizations that receive state funding.

Chapter 10

Submerged Aquatic Vegetation (SAV)

What Are Submerged Aquatic Vegetation (SAV)?

Submerged aquatic vegetation are rooted vascular plants found in the waters of estuaries where the water is shallow and clear enough for sunlight to penetrate the water column so that photosynthesis can occur. SAV is completely submerged and does not include algae or floating plants. Salinity, temperature and substrate determine where each species of SAV can grow. Over the years, SAV beds have declined in the estuarine waters of the Chesapeake Bay and its tributaries. Nutrients, sediments from runoff, and herbicides cause a decline in SAV population.

Why Are SAV Important?

SAV beds provide food and habitat for waterfowl, fish, shellfish, and invertebrates. Juvenile blue crabs and fish use the SAV beds for cover, while the leaves of the plants serve as attachment sites for eggs and small organisms. SAV use up excess nutrients that might contribute to eutrophication of an estuary by storing a summer pulse of nutrients for later release in the fall as the plant material decomposes. SAV beds trap sediment and reduce shoreline erosion by reducing the energy of incoming waves. Photosynthesis of SAV adds oxygen to the water.

Monitoring the Habitat Requirements for SAV

The Alliance for the Chesapeake Bay (ACB) coordinates the monitoring of the water quality requirements for SAV with several other volunteer monitoring organizations. Since available sunlight is the most important factor affecting SAV growth, the amount of light available is measured by various means. ACB uses five measures to define the amount of light available to SAV. Light penetration is measured with a Secchi disk or turbidity tube. Total suspended solids (TSS) and chlorophyll *a* (estimates the amount of algae and plankton) are measured because they block sunlight from SAV. Dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphorus (DIP) are measured because they can lead to algal blooms that can also block sunlight from SAV. All of these parameters, except for light penetration (as measured by the Secchi disk), must be measured in a laboratory from samples collected in the field. Salinity is also recommended as a monitoring parameter in order to determine the basic salinity regime of the site. Please see the chapters in this manual specific to these parameters for more information.

Volunteers filtering water sample for analysis of the water quality requirements for SAV (*photo courtesy of Alliance for the Chesapeake Bay).*

What Do Your SAV Habitat Requirement Results Mean?

This section was adapted from the Chesapeake Bay Program document entitled *Chesapeake Bay Submerged Aquatic Vegetation Water Quality and Habitat-Based Requirements and Restoration Targets: A Second Technical Synthesis* (August 2000).

The Chesapeake Bay Program is the regional partnership that directs and conducts the restoration of the Chesapeake Bay. Monitoring, both pre and post planting, is a crucial component of any SAV planting project. Monitoring is important to identify and prioritize potential restoration sites with sufficient water quality. Likewise, monitoring is important to avoid restoration at a site with poor water quality. Post planting monitoring, including plant survival monitoring, is important in order to provide information about why a restoration project was unsuccessful or successful.

Water quality monitoring results are compared to habitat requirements developed by Chesapeake Bay Program scientists that are believed to be indicative of good water quality conditions conducive to SAV growth and survival (Table 10-1). SAV habitat parameters include primary and secondary requirements. The primary light requirement is the *minimum light requirement*, also known as the *percent light at the leaf* (PLL). This refers to the percent of light measured just below the surface of the water that reaches the surface of an SAV leaf growing at the sediment surface, after passing through the water column and any material that is accumulated on the SAV leaf surface. PLL can be calculated using water quality data of the five parameters collected by ACB volunteers: Secchi depth, dissolved inorganic nitrogen, dissolved inorganic phosphorous, total suspended solids, and chlorophyll *a*. Secondary requirements included these five parameters as well as the *water column light requirement*, also referred to as the *percent light through the water column* (PLW). This refers to the percent of light measured just below the surface of the water that reaches the sediment surface after passing through the overlying water column, but not through the accumulated material on the SAV leaf surface. PLW should only be used to evaluate water quality conditions only if the parameters necessary to calculate PLL are not available. Other secondary habitat requirements include the four laboratory parameters needed in order to calculate PLL (TSS, DIP, DIN, and Chlorophyll *a*). These four parameters are useful as diagnostic tools used to determine possible explanations of non-attainment of the necessary PLL value.

Table 10-1. Habitat requirements for SAV

Habitat Requirement	How Measured	Minimum Level
Primary		
Minimum Light Requirement, also referred to as the Percent Light at the Leaf (PLL)	Calculated using Secchi depth, DIN, DIP, TSS, and Chlorophyll *a*	>9 % (tidal freshwater and low salinity regime) ->15% for medium to high salinity regimes
Secondary		
Water Column Light Requirement, also referred to as the PLW (Percent Light through the Water Column)	Calculated using Secchi Depth or light meter	>13 % (tidal freshwater and low salinity regime) ->22% for medium to high salinity regimes
Dissolved inorganic Nitrogen (DIN)	Filtered water sample	<0.01-0.02 mg/l, depending on salinity regime
Dissolved inorganic Phosphorous (DIP)	Filtered water sample	<0.15 mg/l
Total Suspended Solids (TSS)	Water drawn through a filter	<15 mg/l
Chlorophyll *a* (Chl *a*)	Water drawn through a filter	<15 µg/l (micrograms per liter)
Epiphyte biomass	Lab measurement of epiphyte growth on Mylar strips	___

Summary of SAV Habitat Requirement Monitoring Methods

Method	Approximate Cost	Monitoring Level	Organizations Using Method
SAV Habitat Requirement Monitoring: 1. field measurements: - Secchi depth and/or turbidity tube - salinity 2. lab analysis of dissolved parameters for: ammonia, nitrate, nitrite, orthophosphate, total suspended solids, and chlorophyll *a*	- See Chapters 12 and 13 for field measurements - Lab analysis for all parameters listed: approximately $31 based on 2003 prices	I or II	- Alliance for the Chesapeake Bay and affiliate organizations

Other SAV Activities in Virginia

Since SAV are sensitive to disturbance, volunteer programs working with SAV should receive proper training and guidance from scientists or government agency representatives.

SAV Plantings

The Alliance for the Chesapeake Bay conducts SAV plantings utilizing the assistance of volunteers in an attempt to stimulate the growth of new SAV beds in areas where water quality and other site conditions (wave energy, soil type, etc.) indicate good conditions for plant survival. Planting is accomplished often with the assistance of volunteer SCUBA divers. Fence enclosures are often constructed around the plantings to minimize potential herbivory and disturbance of the plants from wildlife including turtles, fish, invertebrates, and waterfowl. Water quality and plant monitoring are crucial components of any SAV planting project both before and after the planting.

Volunteers planting SAV (*photo courtesy of Alliance for the Chesapeake Bay)*.

The Chesapeake Bay Foundation (CBF) sponsors the "Grasses for the Masses" and "Grasses in Classes" programs where schools or individuals can grow SAV in aquariums and then participate in a planting project to plant the mature grasses in areas where they may be able to survive.

Underwater Grass Mapping (Groundtruthing)

Volunteers throughout the Chesapeake Bay are recruited during the summer annually to help verify the existence of SAV beds shown in aerial photographs, identify the SAV species, and locate any new beds that might exist. This process is called "groundtruthing." This activity is coordinated by the Chesapeake Bay Foundation.

For More Information About SAV Activities

- Monitoring Habitat Requirements or Planting SAV
  ACB: http://www.AllianceChesBay.org
- Classroom – Growing and Planting SAV
  CBF: http:///www.cbf.org
- Mapping SAV
  CBF: http:///www.cbf.org